Osmotic Pressure Measurements of Cane Sugar Solutions at Higher Temperatures.

DISSERTATION

SUBMITTED TO THE BOARD OF UNIVERSITY STUDIES OF JOHNS HOPKINS UNIVERSITY IN CONFORMITY WITH A REQUIREMENT FOR THE DEGREE OF DOCTOR OF PHILOSOPHY.

BY

JOHN BROWN ZINN

BALTIMORE

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OSMOTIC PRESSURE MEASUREMENTS OF CANE SUGAR SOLUTIONS AT HIGHER TEMPERATURES.

HISTORICAL.

Van't Hoff in his paper "The Role of Osmotic Pressure in the Analogy between Solutions and Gases," states that: "The osmotic pressure of a solution of cane-sugar, ascertained directly, is, then, at the same temperature, exactly equal to the gases pressure of a gas which contains the same number of molecules in a given volume as there are cane-sugar molecules in the same volume of the solution."[1]

Ostwald in his book "Solutions," makes the following statement in his treatment of the relation of osmotic pressure to gas pressure: "Dissolved substances exert the same pressure, in the form of osmotic pressure, as they would exert were they gasified, at the same temperature without change of volume."[2]

From the above definitions of the relation of osmotic pressure to gas pressure it seems fair to conclude that these authors used the volume of the solution as their standard of refering one pressure to the other.

But as a supplement to his definition upon the relation of osmotic pressure to gas pressure van't Hoff was particularly careful to emphasize the fact that this relation was only intended for dilute solutions as is shown by a short paragraph taken from his above mentioned paper. After calling attention to the possibility of applying a reversible process to solutions by the use of osmotic pressure he says: "We will now make use of this practical advantage, especially for the investigation of the laws which hold for "ideal solutions," that is, for solutions which are diluted to such an extent that they are comparable with "ideal gases," and in which, therefore, the reciprocal action of the dissolved molecules can be neglected, as also the space occupied by

1. Zeit. phys. chem , **1**, 493
2. Solutions, p 116 (translation by Muir)

the molecules in comparison with the volume of the solution itself."[3]

Thus even though van't Hoff used the volume of the solution as his value of v in the p v KT equation; still it was evident that he saw the possibility of discrepancies occurring in the case of concentrated solutions and in the above points out the two factors that might exert a disturbing influence; namely, the specific attraction between the dissolved molecules and the space occupied by these molecules.

As a matter of fact if there is to be an analogy between solutions and gases we would expect to find abnormal results for concentrated solutions because the law of Boyle, p c = constant does not hold for concentrated gases, that is a gas under high pressure, but instead give pressures which are always abnormally high. A correction for this deviation from the law of Boyle is provided for in the van der Waal equation $(p + \frac{a}{v_2})(v - b) =$ constant, which holds for gases under fairly high pressure, because it corrects for the volume of the gas molecules and the specific attraction between these molecules. It is probable therefore that the abnormally high osmotic pressure of concentrated solutions might be explained and corrected in the same manner.

Ostwald[4] appears to have been the first to suggest the necessity of applying van der Waal's equation to solutions. In his study of electrical conductivity of solutions of a number of organic compounds he found that the constant in his dilution law $\frac{m_2}{(1 - M)} v = K$ decreased with the increase in concentration in the case of concentrated solutions. He thought this irregularity might be corrected by the application of the van der Waal's equation to solution. In order to test this thought he took into account the volume of the dissolved molecules and the inner friction of the solution but neglected the specific attraction of molecules, and by this means was able to obtain very satisfactory constants for concentrated solutions.

3. Zeit. phys. chem., 1, 483
4. Zeit. phys. chem., 2, 280

Brady,[5] in a discussion on the kinetic nature of osmotic pressure, by assuming a specific attraction between the dissolved molecules and the molecules of the solvent and also the attraction of the dissolved molecules and molecules of the solvent among themselves, obtained an equation similar to that of van der Waals by means of which he was able to explain the abnormal results obtained for concentrated solutions in respect to their freezing point depressions.

Beckman[6] and Arrhenius[7] suggested as an explanaton of certain abnormal results obtained by the freezing point lowering, the attraction between the molocules of the dissolved substance also between these and the molocules of the solvent, but they made no attempt to apply any correction for these attractions.

A. A. Noyes[8] has shown how van der Waal's equation can be used for osmotic pressure of solutions. In applying this equation to solutions Noyes disregards the attraction between the dissolved molecules which is so very small in comparison with the total pressure and takes into account only the space occupied by the dissolved molecules and the solvent, from which he works out the equation $p\ (v-d) = K$ in which p is the osmotic pressure, v the volume of the solution which contains a gram molecular weight of the dissolved substance, d a constant which depends upon the volume of the dissolved molecules and the volume of the solvent, and K is a constant which is the molecular osmotic pressure. The value d is determined experimentally from two sets of measurements by using the following equation: $p_1\ (v_1 - d) = p_2\ (v_2 - d)$ in which p_1 and v_1 are the pressure and the volume respectively in one case and p_2 and v_2 have the same significance in the other,

$$\text{therefore } d = \frac{p_2 v_2 - p_1 v_1}{p_2 - p_1}$$

When Noyes applied this correction (d) to some of the irregu-

5. Zeit. phys. chem, 4, 444
6. Ibid., 2, 734
7. Ibid., 2, 499
8. Zeot. phys. chem., 5, 53
9. Zeit. phys. chem., 28, 115

lar freezing point lowerings he obtained a very good constant value for the molecular depression of the freezing point.

Others working in this same field who made use of the van der Waal equation in the study of solutions were Barmwater,[9] Schillings,[10] Loomis,[11] Thos. Ewan,[12] and Abegg.[13]

In the preliminary work on osmotic pressure in this laboratory it soon became evident that the osmotic pressure of cane-sugar solutions do not exactly obey the gas laws as formulated in the original equation of van't Hoff. While this quotation held to within the limits of experimental error for dilute solutons (namely ideal solutions) it did not hold for concentrated solutions. Marked discrepancies were observed in the normal cane-sugar solution which gave a pressure of 31.5 atmospheres at 24° when according to calculations made by means of the van't Hoff equation it should have given 24.25 atmospheres. Instead of obeying the law of Boyle $p\ v = K$ it was found that the product $p\ v$ increases rapidly with increase in concentration.

Accepting the analogy between solutions and gases it seemed quite probable that this variation from the law of Boyle for concentrated solutions could be explained in the same way as the variation found in the case of concentrated gases; that is gases under high pressure, name by the application of the van der Waal equation.

Of the two corrections introduced in the van der Waal equation the correction for the intramolecular attraction and the attraction between the molecules of the solute and the molecules of the solvent is so small in proportion to the total pressure that they can be neglected. The second correcton, namely the volume of the dissolved molecules in concentrated solutions becomes very great in proportion to the whole volume and therefore the volume of the solute molecules must be taken into account. For example the true volume of a gas is not the observed volume but the ob-

10. Progr. d. Oberrealschule in Olmutz, 189 3-4. 23
11. Zeit. phys. chem., 37, 487
12. Ibid., 14, 417
13. Ibid., 15. 254

served volume minus the volume of the gaseous particles, therefore in dealing with solutions we must subtract the volume of the molecules of the dissolved substance from the whole volume of the solution in order to get the actual or true volume of the solution.

It was proposed to introduce a correction for the volume of the solute molecules which would be automatic in character, which was made possible by the adoption of the weight normal system for making up solutions. A short account of how Morse and Frazer were led to the adoption of the weight normal system is given in the following: "Soon after beginning the measurements of the osmotic pressure of cane-sugar under conditions which gave to the results a considerable degree of precision, it became apparent that the mass of the solvent plays a part which appears to have been unsuspected hitherto. We found—or appeared to discover—that a gram-molecular weight of the substance, dissolved in water and diluted to a litre volume, is not the normal standard for osmotic pressure. On the other hand, (when we dissolved a gram-molecular weight of cane-sugar (342.22 grams) in 1000 grams of water, i. e., in that mass of the solvent which has the unit volume 1 litre at the temperature of maximum density we found its osmotic pressure at about 20 degrees in quite close accord with the pressure which a gram-molecular weight of hydrogen would exert, at the same temperature, if its volume were reduced to 1 litre; i. e., to that volume which the unit mass of the solvent has at the temperature of greatest density).[14]

It was thus that the change from volume normal to weight normal was made and now we always have the same mass of solvent coming into play no matter what the concentration of the solution. In other words we have corrected experimentally for the b in the van der Waal's equation as applied to solutions $(p + \frac{a}{v_2})(v - b) = \text{constant}$, in which b is the volume of the dissolved molecules.

Even after the adoption of the weight normal basis which ap-

14. Ams. chem. J., 34, 28

parently should be the standard for most physical chemical work still the osmotic pressures, measured with .1 to 1. normal cane-sugar solutions at temperatures ranging from 0° to 25° were all somewhat higher than the calculated gas pressure. The calculated pressures being determined on the assumption that cane-sugar dissolved in water exerts an osmotic pressure equal to that which it would exert if it were gasified at the same temperature and the volume of the gas were reduced to that of the solvent in the pure state which reduced to equation form would be stated thus $p\ v = K\ T$ in which p is the pressure, v the volume of the solvent in the pure state, K the constant for any gas, and T the absolute temperature.

This equation $p\ v = K\ T$ can also be written $p\ (v - b) = K\ T$ in which v is the volume of the solution and b the volume of the solute molecules. In this second equation v has the same significance as the v in the original equation of van't Hoff and perhaps the comparison with the van der Waal equation can be made clearer by writing the equation in this form: $p\ (v - b) = K\ T$. The theoretical gas pressures in all the work on osmotic pressure carried out in this laboratory have been calculated from this equation, the b being automatically corrected for by means of the weight normal system.

By consulting Table I (p. 11) it it at once apparent that the relation between osmotic pressure and gas pressure is not unity for cane-sugar solutions ranging in concentration from .1 to 1. normal and extending over a range in temperature from 0° to 25°, but although this relation is constant for each concentration at the different temperatures nevertheless the osmotic pressures are always higher than the gas pressures calculated by means of the above equation. Thus it seemed quite probable that a further correction ought to be added to the equation $p\ (v - b) = K\ T$.

If we again consider van der Waal's equation $(p + \frac{a}{v_2})\ (v - b) = K\ T$ it is observed that he corrected not only for the volume of the gaseous molecules but also for the specific attraction between the gas molecules. Now in solutions we have not only the

Table I

Temp.	Weight-normal concentration									
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
	Ratio of osmotic to gas pressure									
0°	(1.106)	1.061	1.061	1.060	1.069	1.077	1.083	1.093	1.104	1.115
5°	1.082	1.063	1.058	1.059	1.067	1.074	1.084	1.093	1.102	1.115
10°	1.082	1.060	1.059	1.060	1.066	1.073	1.083	1.092	1.102	1.113
15°	1.082	1.061	1.061	1.059	1.068	1.073	1.083	1.093	1.102	1.115
20°	1.084	1.062	1.060	1.060	1.067	1.073	1.084	1.093	1.103	1.115
25°	1.084	1.059	1.060	1.059	1.065	1.071	1.083	1.093	1.102	1.113
Mean	1.083	1.061	1.060	1.060	1.067	1.074	1.083	1.093	1.103	1.114

attraction between the solute molecules (corresponding to the gas molecules when dealing with a gas) but also the attraction between the solvent molecules and the attraction between the molecules of the solvent and the solute. It therefore seemed quite probable that a correction term, similar but more complex to the $-\frac{a}{v_2}$ in the van der Wall equation ought to be added to the equation $p\ (v - b) = K\ T$ in order to make this equation a perfectly rigid one for solutions. However in as much as at higher temperatures the osmotic pressure corresponds to the pressures calculated by means of the simple formula $p\ (v - b) = K\ T$, b being automatically corrected by use of the weight normal system it would appear that all intermolecular attractions play but a little part and that the excess pressures are due to hydration.

Hydration is due to the tendency of the solute and solvent to combine, therefore in solution this union of solute and solvent results in the removal of a certain amount of the solvent and a corresponding increase in the concentration of the solution which tends to produce a higher osmotic pressure. This phenomenon becomes more pronounced at lower temperatures as we would expect due to the fact that hydrates are more complex at lower temperatures.

Cane-sugar being one of the substances which show this property in solution it seems probable that this may account for the apparent non-conformity to the law of Boyle, of the osmotic pressures of can-sugar solutions determined at lower temperatures.

Before giving a list of the measurements which I made with the collaboration of Dr. Holland, I would like to point out one more very important relation brought out by Table I.

It will be noticed that the relation between osmotic pressure and gas pressure for any one concentration is constant irrespective of the temperature thus showing that the law of Gay-Lussac, (which states that pressure increases $\frac{1}{273}$ of itself for every degree rise in temperatures, volume being constant) holds to within the limits of experimental error for cane-sugar solutions but this

work gives no evidence for or against the application of the law of Boyle as applied to solutions. Therefore the hope of ascertaining whether the law of Boyle was applicable to cane-sugar solutions made the work at higher temperatures so extremely desirable, for if these high ratios were due to hydration then it was probable that they would disappear at some higher temperatures due to the dissociation of the complex hydrates.

The following tables are a brief outline of some of the measurements made at higher temperatures and for a more complete discussion of the work consult American Chemical Journal Vol. 58, No. 1.

MEASUREMENTS.

Table II

0.1 Wt. normal solution. Expt. 1 at 30°. Cell Ni_2. Resistance of membrane (nickel ferrocyanide), 500,000 ohms. Manometer 1. Calc. gas pressure, 2.472 atms. Time of setting up cell, April 6, 1911. Barometer during final record: max., 1.010; min., 0.990. Total pressures after cell became constant:

Final Record

	Atms.		Atms.		Atms.
April 21,	3.482	April 25,	3.477	April 28,	3.484
22,	3.465	26,	3.481	29,	3.467
23,	3.492	27,	3.482	30,	3.463
24,	3.488			(10 days.)	

Mean total pressure, April 21-30 = 3.4781 atms.
Mean barom. pressure, April 21-30 = 1.0025 atms.
Mean osmot. pressure, April 21-30 = 2.4756 atms.

Table III

0.1 Wt. normal solution. Expt 2 at 30°. Cell K_2. Resistance, 250,000 ohms. Manometer 15. Calc. gas pressure, 2.472 atms. Time of setting up cell, November 13, 1911. Barometer during final record: max., 1.009; min., 0.982. Total daily pressures:

Final Record

	Atms.		Atms.		Atms.
Nov. 14,	3.482	Nov. 18,	3.462	Nov. 22,	3.474
15,	3.468	19,	3.466	23,	3.475
16,	3.463	20,	3.462	24,	3.475
17,	3.465	21,	3.466	(11 days)	

Mean total pressure, Nov. 14-24 = 3.4681 atms.
Mean barom. pressure, Nov. 14-24 = 0.996 atms.
Mean osmot. pressure, Nov. 14-24 = 2.4721 atms.
Mean osmotic pressure of Expts. 1 and 2 = 2.474 atms.
Ratio of osmotic to calculated gas pressure 1.000.

Table IV

0.1 Wt. normal solution. Expt. 1 at 50°. Cell U_5. Resistance, 55,000 ohms. Manometer 1. Calc. gas pressure, 2,635 atms. Time of setting up cell, Dec. 7, 1911. Barometer during final record: max., 1.014; min., 0.981. Total pressures after cell became constant:

Final Record

	Atms.		Atms.		Atms.
Dec. 17,	3.650	Dec. 21,	3.649	Dec. 25,	3.650
18,	3.646	22,	3.644	26,	3.644
19,	3.643	23,	3.646	27,	3.643
20,	3.648	24,	3.650	28,	3.644

Mean total pressure, Dec. 17-28 = 3.646 atms.
Mean barom. pressure, Dec. 17-28 = 1.003 atms.
Mean osmot. pressure, Dec. 17-29 = 2.643 atms.

Table V

0.1 Wt. normal solution. Expt. 2 at 50°. Cell E_5. Resistance, 100,000 ohms. Manometer 15. Calc. gas pressure, 2.635 atms. Time of setting up cell, Dec. 8, 1911. Barometer during final record: max., 1.014; min., 0.989. Total pressures after cell became constant:

Final Record

	Atms.		Atms.		Atms.
Dec. 17,	3.644	Dec. 21,	3.642	Dec. 24,	3.635
18,	3.637	22,	3.637	25,	3.635
19,	3.642	23,	3.635	26,	3.635
20,	3.646			(10 days)	

Mean total pressure, Dec. 17-26 = 3.6388 atms.
Mean barom. pressure, Dec. 17-26 = 1.005 atms.
Mean osmot. pressure, Dec. 17-26 = 2.6338 atms.

Table VI

0.1 Wt. normal solution. Expt. 3 at 50°. Cell V_5. Resistance, 110,000 ohms. Manometer 9. Calc. gas pressure, 2.635 atms. Time of setting up cell, Dec. 12, 1911. Barometer during final record: max., 1.014; min., 0.981. Total pressures after cell became constant:

Final Record

	Atms.		Atms.		Atms.
Dec. 18,	3.632	Dec. 22,	3.629	Dec. 26,	3.630
19,	3.627	23,	3.629	27,	3.624
20,	(not rec'd)	24,	3.629	28,	3.629
21,	(not rec'd)	25,	3.630	(11 days)	

Mean total pressure, Dec. 18-28 = 3.629 atms.
Mean barom. pressure, Dec. 18-28 = 1.000 atms.
Mean osmot. pressure, Dec. 18-28 = 2.629 atms.
Mean osmotic pressure of Expts. 1, 2 and 3 = 2.6353.
Ratio of osmotic to gas pressure = 1.000.

Table VII

0.1 Wt. normal solution. Expt. 1 at 60°. Cell W_6. Resistance, 37,000 ohms. Manometer 15. Calc. gas pressure, 2.717 atms. Time of setting up cell, Feb. 15, 1912. Barometer during final record. max., 1.018; min., 0.983. Total pressures after cell became constant:

Final Record

	Atms.		Atms.		Atms.
Feb. 25,	3.724	Feb. 29,	3.720	Mar. 3,	3.732
26,	3.721	Mar. 1,	3.729	4,	3.730
27,	3.720	2,	3.731	5,	3.731
28,	3.714				

Mean total pressure, Feb. 25-Mar. 5 = 3.7252 atms.
Mean barom. pressure, Feb 25-Mar. 5 = 1.005 atms.
Mean osmot. pressure, Feb. 25-Mar. 5 = 2.7202 atms.

Table VIII

0.1 Wt. normal solution. Expt. 2 at 60°. Cell B_9. Resistance, 37,000 ohms. Manometer 11. Calc. gas pressure, 2.717 atms. Time of setting up cell, Feb. 15, 1912. Barometer during final record: max., 1.018; min., 0.983. Total pressures after cell became constant·

Final Record

	Atms.		Atms.		Atms.
Feb. 25,	3.718	Feb. 29,	3.713	Mar. 4,	3.726
26,	3.719	Mar. 1,	3.718	5,	3.726
27,	3.716	2,	3.722	(10 days)	
28,	3.708	3,	3.726		

Mean total pressure, Feb. 25-Mar. 5 = 3.7192 atms.
Mean barom. pressure, Feb. 25-Mar. 5 = 1.005 atms.
Mean osmot. pressure, Feb. 25-Mar. 5 = 2.7142 atms.
Mean osmotic pressure of Expts, 1 and 2 = 2.7172 atms.
Ratio of osmotic to gas pressure = 1.000

Table IX

0.2 Wt. normal solution. Expt. 1 at 30°. Cell C_5. Resistance, 120,000 ohms. Manometer 9. Calc. gas pressure, 4.943 atms Time of setting up cell, October 30, 1911. Barometer during final record: max., 1.018; min., 0.989. Total daily pressures:

Final Record

	Atms.		Atms.		Atms.
Nov. 2,	6.049	Nov. 6,	6.045	Nov. 9,	6.046
3,	6.031	7,	6.045	10,	6.046
4,	6.039	8,	6.044	11,	6.046
5,	6.046			(10 days)	

Mean total pressure, Nov. 2-11 = 6.0437 atms.
Mean barom. pressure, Nov. 2-11 = 1.004 atms.
Mean osmot. pressure, Nov. 2-11 = 5.0397 atms.

Table X.

0.2 Wt. normal solution. Expt. 2 at 30°. Cell L_5. Resistance, 150,000 ohms. Manometer 20. Calc. gas pressure, 4.943 atms. Time of setting up cell, October 30, 1911. Barometer during final record: max., 1.018; min., 0.989. Total daily pressures:

Final Record

	Atms.		Atms.		Atms.
Nov. 3,	6.056	Nov. 7,	6.042	Nov. 11,	6.041
4,	6.052	8,	6.040	12,	6.039
5,	6.050	9,	6.038	13,	6.053
6,	6.046	10,	6.041	(11 days)	

Mean total pressure, Nov. 3-13 = 6.0498 atms.
Mean barom. pressure, Nov. 3-13 = 1.002 atms.
Mean osmot. pressure, Nov 3-13 = 5.0478 atms.
Mean osmotic pressure for Expts. 1 and 2 = 5.0438 atms.
Ration of osmotic to gas pressure = 1.020.

Table XI

0.2 Wt. normal solution. Expt. 1 at 50°. Cell L_5. Resistance, 75,000 ohms. Manometer 29. Calc. gas pressure, 5.27 atms. Time of setting up cell, November 28, 1911. Barometer during final record: max., 1.011; min., 0.997. Total pressures after cell became constant:

Final Record

	Atms.		Atms.		Atms.
Dec. 4,	6.281	Dec. 8,	6.284	Dec. 11,	6.285
5,	6.263	9,	6.285	12,	6.288
6,	6.277	10,	6.283	13,	6.287
7,	6.280				(10 days)

Mean total pressure, Dec. 4-13 = 6.2813 atms.
Mean barom. pressure, Dec. 4-13 = 1.008 atms.
Mean osmot. pressure, Dec. 4-13 = 5.2733 atms.

Table XII

0.2 Wt. normal solution. Expt. 2 at 50°. Cell S_5. Resistance, 65,000 ohms. Manometer 39. Calc. gas pressure, 5.27 atms. Time of setting up cell, November 28, 1911. Barometer during final record: max., 1.011; min., 0.997. Total pressures after cell became constant:

Final Record

	Atms.		Atms.		Atms.
Dec. 5,	6.266	Dec. 9,	6.300	Dec. 12,	6.301
-6,	6.290	10,	6.300	13,	6.299
7,	6.300	11,	6.300	14,	6.295
8,	6.299				(10 days)

Mean total pressure, Dec. 5-14 = 6.295 atms.
Mean barom pressure, Dec. 5-14 = 1.009 atms.
Mean osmot. pressure Dec. 5-14 = 5.285 atms.

Table XIII

0.2 Wt. normal solution. Expt. 3 at 50°. Cell R_5. Resistance, 80,000 ohms. Manometer 27. Calc. gas pressure, 5,27 atms. Time of setting up cell, November 28, 1911. Barometer during final record: max., 1.001; min., 0.997. Total daily pressures:

Final Record

	Atms.		Atms.		Atms.
Dec. 3,	6.274	Dec. 7,	6.277	Dec. 11,	6.283
4,	6.316	8,	6.279	12,	6.27
5,	6.284	9,	6.282	13,	6.282
6,	6.284	10,	6.279	(11 days)	

Mean total pressure, Dec. 3-13= 6.284 atms
Mean barom. pressure, Dec. 3-13 = 1.007 atms.
Mean osmot. pressure, Dec. 3-13 = 5.277 atms.
Mean osmotic pressure of Expts. 1, 2 and 3 = 5.2784 atms.
Ratio of osmotic to gas pressure = 1.0016

Table XIV.

0.2 Wt. normal solution. Expt. 1 at 60°. Cell E_5. Resistance, 50,000 ohms. Manometer 1. Calc. gas pressure, 5.433 atms. Time of setting up cell, February 7, 1911. Barometer during final record: max., 1.013; min., 0.982. Total pressures after cell became constant:

Final Record

	Atms.		Atms.		Atms.
Feb. 13,	6.457	Feb. 17,	6.452	Feb. 21,	6.414
14,	6.449	18,	6.445	22,	6.417
15,	6.441	19,	6.444	23,	6.436
16,	6.456	20,	6.449	(11 days)	

Mean total pressure, Feb. 13-23 = 6.446 atms.
Mean barom. pressure, Feb. 13-23 = 0.996 atms.
Mean osmot. pressure, Feb. 13-23 = 5.450 atms.

Table XV

0.2 Wt. normal solution. Expt. 2 at 60°. Cell K_5. Resistance, 61,000 ohms. Manometer 1. Calc. gas pressure, 5.433 atms. Time of setting up cell, February 26, 1911. Barometer during final record: max., 1.013; min., 0.987. Total pressures after cell became constant:

Final Record.

	Atms.		Atms.		Atms.
Mar. 6,	6.442	Mar. 9,	4.429	Mar. 12,	4.432
7,	6.420	10,	4.430	13,	4.411
8,	6.423	11,	4.427	14,	4.416

Mean total pressure, Mar. 6-14 = 6.4256 atms.
Mean barom. pressure, Mar. 6-14 = 1.001 atms.
Mean osmot. pressure, Mar. 6-14 = 5.4246 atms.
Mean osmotic pressure of Expts, 1 and 2 = 5.4373 atms.
Ratio of osmotic to gas pressure = 1.0008

Table XVI.

0.3 Wt. normal solution. Expt. 1 at 30°. Cell B_5. Resistance, 110,000 ohms. Manometer 11. Calc. gas pressure, 7.415 atms. Time of setting up cell, October 25, 1911. Barometer during final record: max., 1.018; min., 0.989. Total pressures after cell became constant:

Final Record

	Atms.		Atms.		Atms.
Nov. 2,	8.660	Nov. 6.	8.646	Nov. 9,	8.641
3.	8.654	7,	8.638	10,	8.644
4,	8.640	8,	8.637	11,	8.643
5,	8.646				

Mean total pressure, Nov. 2-11 = 8.6449 atms.
Mean barom. pressure, Nov. 2-11 = 1.004 atms.
Mean osmot. pressure, Nov. 2-11 = 7.6409 atms.

Table XVII.

0.3 Wt. normal solution. Expt. 2 at 30°. Cell H_5. Resistance, 110,000 ohms. Manometer 24. Calc. gas pressure, 7.415 atms. Time of setting up cell, October 25, 1911. Barometer during final record: max., 1.018; min., 0.989. Total pressures after cell became constant:

Final Record

	Atms.		Atms.		Atms.
Nov. 3,	8.685	Nov. 6,	8.668	Nov. 9,	8.652
4,	8.675	7,	8.648	9,	8.652
5,	8.675	8,	8.650	11,	8.651

Mean total pressure, Nov. 3-11 = 8.6556 atms.
Mean barom. pressure, Nov. 3-11 = 1.003 atms.
Mean osmot. pressure, Nov. 3-11 = 7.6526 atms.
Mean of osmotic pressures of Expts, 1 and 2 = 7.6468 atms.
Ratio of osmotic to gas pressure = 1.031.

Table XVIII.

0.3 Wt. normal solution. Expt. 1 at 50°. Cell B_5. Resistance, 75,000 ohms. Manometer 38. Calc. gas pressure, 7.905 atms. Time of setting up cell, December 6, 1911. Barometer during final record: max., 1.013; min., 0.981. Total pressures after cell became constant:

Final Record

	Atms.		Atms.		Atms.
Dec. 20,	8.945	Dec. 23,	8.968	Dec. 26,	8.968
21,	8.950	24,	8.968	27,	8.961
22,	8.962	25,	8.967	28,	8.964

Mean total pressure, Dec. 20-28 = 8.961 atms.
Mean barom. pressure, Dec. 20-28 = 1.001 atms.
Mean osmot. pressure, Dec. 20-28 = 7.960 atms.

Table XIX

0.3 Wt. normal solution. Expt. 2 at 50°. Cell T_5. Resistance, 60,000 ohms. Manometer 5. Calc. gas pressure, 7.905 atms. Time of setting up cell, December 6, 1911. Barometer during final record: max., 1.014; min., 0.991. Total pressures after cell became constant:

Final Record

	Atms.		Atms.		Atms.
Dec. 14,	9.005	Dec. 18,	8.978	Dec. 21,	9.003
15,	8.995	19,	8.994	22,	8.995
16,	8.976	20,	9.012	23,	8.991
17,	8.980				(10 days)

Mean total pressure, Dec. 14-23 = 8.9929 atms.
Mean barom. pressure, Dec. 14-23 = 1.005 atms.
Mean osmot. pressure, Dec. 14-23 = 7.9879 atms.

Table XX.

0.3 Wt. normal solution. Expt. 3 at 50°. Cell P_5. Resistance, 75,000 ohms. Manometer 2. Calc. gas pressure, 7.905 atms. Time of setting up cell, December 19, 1911. Barometer during final record: max., 1.009; min., 0.981. Total daily pressures:

Final Record

	Atms.		Atms.		Atms.
Dec. 22,	8.970	Dec. 26,	8.978	Dec. 29,	8.942
23,	8.981	27,	9.001	30,	8.981
24,	8.978	28,	8.959	31,	8.925
25,	8.992				(10 days)

Mean total pressure, Dec. 22-31 = 8.9707 atms.
Mean barom. pressure, Dec. 22-31 = 0.997 atms.
Mean osmot. pressure, Dec. 22-31 = 7.9737 atms.
Mean osmotic pressure of Expts. 1, 2 and 3 = 7.9739 atms.
Ratio of osmotic to gas pressure = 1.0087

Table XXI.

0.3 Wt. normal solution. Expt. 1 at 60°. Cell K_5. Resistance, 75,000 ohms. Manometer 15. Calc. gas pressure, 8.150 atms. Time of setting up cell, January 25, 1912. Barometer during final record: max., 1.013; min., 0.995. Total pressures after cell became constant:

Final Record

	Atms.		Atms.		Atms.
Feb. 6,	9.147	Feb. 10,	9.142	Feb. 13,	9.157
7,	9.137	11,	9.151	14,	9.160
8,	9.155	12,	9.161	15,	9.156
9,	9.156			(10 days)	

Mean total pressure, Feb. 6-15 = 9.1522 atms.
Mean barom. pressure, Feb. 6-15 = 1.000 atms.
Mean osmot. pressure, Feb. 6-15 = 8.1522 atms.

Table XXII.

0.3 Wt. normal solution. Expt. 2 at 60°. Cell F_5. Resistance, 75,000 ohms. Manometer 11. Calc. gas pressure, 8.150 atms. Time of setting up cell, January 25, 1912. Barometer during final record: max., 1.013; min., 0.995. Total pressures after cell became constant:

Final Record

	Atms.		Atms.		Atms.
Feb. 6,	9.133	Feb. 10,	9.130	Feb. 13,	9.123
7,	9.153	11,	9.117	14,	9.134
8,	9.136	12,	9.114	15,	9.134
9,	9.109			(10 days)	

Mean total pressure, Feb. 6-15 = 9.1283 atms.
Mean barom. pressure, Feb. 6-15 = 1.000 atm.
Mean osmot. pressure, Feb. 6-15 = 8.1283 atms.
Mean osmotic pressure for Expts. 1 and 2 = 8.1403 atms.
Ratio of osmotic to gas pressure = 0.999

Table XXIII

0.4 Wt. normal solution. Expt. 1 at 30°. Cell L_5. Resistance, 110,000 ohms. Manometer 29. Calc. gas pressure, 9.886 atms. Time of setting up cell, October 13, 1911. Barometer during final record: max., 1.014; min., 0.995. Total pressures after cell became constant:

Final Record

	Atms.		Atms.		Atms.
Oct. 20,	11.309	Oct. 22,	11.305	Oct. 24,	11.294
21,	11.313	23,	11.305	25,	11.313

Mean total pressure, Oct. 20-25 = 11.307 atms.
Mean barom. pressure, Oct. 20-25 = 1.002 atms.
Mean osmot. pressure, Oct. 20-25 = 10.305 atms.

Table XXIV.

0.4 Wt. normal solution. Expt. 2 at 30°. Cell C_5. Resistance, 250,000 ohms. Manometer 24. Calc. gas pressure, 9.886 atms. Time of setting up cell, October 13, 1911. Barometer during final record: max., 1.014; min., 0.989. Total daily pressures:

Final Record

	Atms.		Atms.		Atms.
Oct. 16,	11.297	Oct. 20,	11.286	Oct. 23,	11.284
17,	11.278	21,	11.287	24,	11.287
18,	11.279	22,	11.284	25,	11.292
19,	11.271				(10 days)

Mean total pressure, Oct. 16-25 = 11.285 atms.
Mean barom pressure, Oct. 16-25 = 1.000 atm.
Mean osmot. pressure, Oct. 16-25 = 10.285 atms.
Mean osmotic pressure of Expts. 1 and 2 = 10.295 atms.
Ratio of osmotic to gas pressure = 1.040.

Table XXV.

0.4 Wt. normal solution. Expt. 1 at 50°. Cell S_5. Resistance, 71,000 ohms. Manometer 38. Calc. gas pressure, 10.540 atms. Time of setting up cell, January 4, 1912. Barometer during final record: max., 1.019; min., 0.988. Total pressure after cell became constant:

Final Record

	Atms.		Atms.		Atms.
Jan. 11,	11.750	Jan. 15,	11.742	Jan. 18,	11.731
12,	11.759	16,	11.738	19,	11.725
13,	11.750	17,	11.732	20,	11.726
14,	11.748				(10 days)

Mean total pressure, Jan. 11-20 = 11.740 atms.
Mean barom. pressure, Jan. 11-20 = 1.003 atms.
Mean osmot. pressure, Jan. 11-20 = 10.737 atms.

Table XXVI.

0.4 Wt. normal solution. Expt. 2 at 50°. Cell H_5. Resistance, 190,000 ohms. Manometer 4. Calc. gas pressure, 10.540 atms. Time of setting up cell, January 4, 1912. Barometer during final record: max., 1.019; min., 0.988. Total pressures after cell became constant:

Final Record

	Atms.		Atms.		Atms.
Jan. 11,	11.695	Jan. 15,	11.724	Jan. 18,	11.711
12,	11.704	16,	11.711	19,	11.702
13,	11.718	17,	11.713	20,	11.724
14,	11.729				(10 days)

Mean total pressure, Jan. 11-20 = 11.713 atms.
Mean barom. pressure, Jan. 11-20 = 1.003 atms.
Mean osmot. pressure, Jan. 11-20 = 10.710 atms.
Mean osmotic pressure for Expts. 1 and 2 = 10.724 atms.
Ratio of osmotic to gas pressure = 1.017.

Table XXVII.

0.4 Wt. normal solution. Expt. 1 at 60°. Cell G_3. Resistance, 28,000 ohms. Manometer 39. Calc. gas pressure, 10.867 atms. Time of setting up cell, February 12, 1912. Barometer during final record: max., 1.018; min., 0.983. Total pressures after cell became constant:

Final Record

	Atms.		Atms.		Atms.
Feb. 23,	11.892	Feb. 27,	11.877	Mar. 2,	11.885
24,	11.858	28,	11.869	3,	11.886
25,	11.868	29,	11.874	4,	11.887
26,	11.853	Mar. 1,	11.886		(11 days)

Mean total pressure, Feb. 23-Mar. 4 = 11.876 atms.
Mean barom. pressure, Feb. 23-Mar. 4 = 1.005 atms.
Mean osmot. pressure, Feb. 23-Mar. 4 = 10.871 atms.

Table XXVIII.

0.4 Wt. normal solution. Expt. 2 at 60°. Cell F_3. Resistance, 57,500 ohms. Manometer 5. Calc. gas pressure, 10.867 atms. Time of setting up cell, February 26, 1912. Barometer during final record: max., 1.018; min., 0.994. Total pressures after cell became constant:

Final Record

	Atms.		Atms.		Atms.
Mar. 3,	11.889	Mar. 6,	11.858	Mar. 9,	11.850
4,	11.862	7,	11.848	10,	11.862
5,	11.882	8,	11.827	11,	11.858

Mean total pressure, Mar. 3-11 = 11.860 atms.
Mean barom. pressure, Mar. 3-11 = 1.007 atms.
Mean osmot. pressure, Mar. 3-11 = 10.853 atms.

Table XXIX.

0.4 Wt. normal solution. Expt. 3 at 60°. Cell C_5. Resistance, 16,000 ohms. Manometer 2. Calc. gas pressure, 10.867 atms. Time of setting up cell, February 26, 1912. Barometer during final record: max., 1.018; min., 0.994. Total daily pressures:

Final Record

	Atms.		Atms.		Atms.
Feb. 29,	11.900	Mar. 4,	11.863	Mar. 7,	11.886
Mar. 1,	11.858	5,	11.877	8,	11.890
2,	11.891	6,	11.890	9,	11.880
3,	11.890				(10 days)

Mean total pressure, Feb. 29-Mar. 9 = 11.883 atms.
Mean barom. pressure, Feb. 29-Mar. 9 = 1.010 atms.
Mean osmot. pressure, Feb. 29-Mar. 9 = 10.873 atms.
Mean osmotic pressure for Expts. 1, 2 and 3 = 10.866 atms.
Ratio of osmotic to gas pressure = 1.000

Table XXX.

0.5 Wt. normal solution. Expt. 1 at 30°. Cell I_5. Resistance, 110,000 ohms. Manometer 4. Calc. gas pressure, 12.358 atms. Time of setting up cell, October 10, 1911. Barometer during final record: max., 1.014; min., 0.989. Total pressures after cell became constant:

Final Record

	Atms.		Atms.		Atms.
Oct. 17,	13.996	Oct. 20,	13.974	Oct. 23,	13.974
18,	13.976	21,	13.976	24,	13.990
19,	13.966	22,	13.972	25,	14.000

Mean total pressure, Oct. 17-25 = 13.9804 atms.
Mean barom. pressure, Oct. 17-25 = 1.000 atms.
Mean osmot. pressure, Oct. 17-25 = 12.9804 atms.

Table XXXI.

0.5 Wt. normal solution. Expt. 2 at 30°. Cell O_5. Resistance, 100,000 ohms. Manometer 15. Calc. gas pressure, 12 358 atms. Time of setting up cell, October 19, 1911. Barometer during final record: max., 1.014; min., 0.995. Total daily pressures:

Final Record

	Atms.		Atms.		Atms.
Oct. 21,	13.962	Oct. 25,	13.986	Oct. 28,	13.986
22,	13.971	26,	13.981	29,	13.981
23,	13.975	27,	13.982	30,	13.981
24,	13.979				(10 days)

Mean total pressure, Oct. 21-30 = 13.9784 atms.
Mean barom pressure, Oct. 21-30 = 1.003 atms.
Mean osmot. pressure, Oct. 21-30 = 12.9754 atms.
Mean osmotic pressure for Expts. 1 and 2 = 12.9779 atms.
Ratio of osmotic to gas pressure = 1.050

Table XXXII.

0.5 Wt. normal solution. Expt. 1 at 50°. Cell I_5. Resistance, 81,000 ohms. Manometer 1. Calc. gas pressure, 13.175 atms. Time of setting up cell, January 4, 1912. Barometer: max., 1.019; min., 0.988. Total pressures after cell became constant:

Final Record

	Atms.		Atms.		Atms.
Jan. 10,	14.534	Jan. 14,	14.501	Jan. 17,	14.493
11,	14.511	15,	14.512	18,	14.496
12,	14.541	16,	14.527	19,	14.512
13,	14.541				(10 days)

Mean total pressure, Jan. 10-19 = 14.5168 atms.
Mean barom pressure, Jan. 10-19 = 1.002 atms.
Mean osmot pressure, Jan. 10-19 = 13.5148 atms.

Table XXXIII.

0.5 Wt. normal solution. Expt. 2 at 50°. Cell F_3. Resistance, 377,000 ohms. Manometer 29. Calc. gas pressure, 13.175 atms. Time of setting up cell, January 4, 1912. Barometer during final record: max., 1.019; min., 0.988. Total pressures after cell became constant:

Final Record

	Atms.		Atms.		Atms.
Jan. 10,	14.416	Jan. 14,	14.515	Jan. 17,	14.524
11,	14.451	15,	14.513	18,	14.518
12,	14.487	16,	14.520	19,	14.504
13,	14.499				(10 days)

Mean total pressure, Jan. 10-19 = 14.4947 atms.
Mean barom. pressure, Jan. 10-19 = 1.002 atms.
Mean osmot. pressure, Jan. 10-19 = 13.4927 atms.

Table XXXIV.

0.5 Wt. normal solution. Expt. 3 at 50°. Cell L_5. Resistance, 94,000 ohms. Manometer 9. Calc. gas pressure, 13.175 atms. Time of setting up cell, January 4, 1912. Barometer during final record: max., 1.019; min., 0.988. Total pressures after cell became constant:

Final Record

	Atms.		Atms.		Atms.
Jan. 10,	14.435	Jan. 14,	14.526	Jan. 17,	14.518
11,	14.487	15,	14.511	18,	14.522
12,	14.522	16,	14.524	19,	14.508
13,	14.504				(10 days)

Mean total pressure, Jan. 10-19 = 14.5057 atms.
Mean barom. pressure, Jan. 10-19 = 1.002 atms.
Mean osmot. pressure, Jan. 10-19 = 13.5037 atms.
Mean osmotic pressure for Expts. 1, 2 and 3 = 13.5037 atms.
Ratio of osmotic to gas pressure = 1.025

Table XXXV.

0.5 Wt. normal solution. Expt. 1 at 60°. Cell V_5. Resistance, 11,600 ohms. Manometer 31. Calc. gas pressure, 13.584 atms. Time of setting up cell, Feb. 23, 1912. Barometer during final record: max., 1.018; min., 0.994. Total pressures after cell became constant:

Final Record

	Atms.		Atms.		Atms.
Mar. 2,	14.654	Mar. 6,	14.646	Mar. 10,	14.649
3,	14.654	7,	14.643	11,	14.654
4,	14.645	8,	14.688	12,	14.655
5,	14.634	9,	14.661		(11 days)

Mean total pressure, Mar. 2-12 = 14.653 atms.
Mean barom. pressure, Mar. 2-12 = 1.008 atms.
Mean osmot. pressure, Mar. 2-12 = 13.645 atms.

Table XXXVI.

0.5 Wt. normal solution. Expt. 2 at 60°. Cell C_5. Resistance, 50,000 ohms. Manometer 4. Calc. gas pressure, 13.584 atms. Time of setting up cell, March 15,1912. Barometer during final record: max., 1.014; min., 0.984. Total daily pressures:

Final Record

	Atms.		Atms.		Atms.
Mar. 18,	14.637	Mar. 22,	14.759	Mar. 25,	14.703
19,	14.608	23,	14.773	26,	14.707
20,	14.620	24,	14.724	27,	14.707
21,	14.635				(10 days)

Mean total pressure, Mar. 18-27 = 14.6873 atms.
Mean barom. pressure, Mar. 18-27 = 1.000 atms.
Mean osmot. pressure, Mar. 18-27 = 13-6873 atms.
Mean osmotic pressure for Expts. 1 and 2 = 13.662 atms.
Ratio of osmotic to gas pressure = 1.0057

Table XXXVII.

0.5 Wt. normal solution. Expt. 1 at 70°. Cell E_5. Resistance, 13,000 ohms. Manometer 1. Calc. gas pressure, 13.992 atms. Time of setting up cell, May 13, 1912. Barometer during final record: max., 1.005; min., 0.982. Total daily pressures:

Final Record

	Atms.		Atms.		Atms.
May 16,	15.015	May 18,	14.985	May 20,	14.974
17,	14.986	19,	14.978		

Mean total pressure, May 16-20 = 14.988 atms.
Mean barom. pressure, May 16-20 = 0.994 atms.
Mean osmot. pressure, May 16-20 = 13.994 atms.

Table XXXVIII.

0.5 Wt. normal solution. Expt. 2 at 70°. Cell L_5. Resistance, 9,600 ohms. Manometer 38. Calc. gas pressure, 13.992 atms. Time of setting up cell, May 13, 1912. Barometer during final record: max., 1.004; min., 0.982. Total daily pressures:

Final Record

	Atms.		Atms.		Atms.
May 15,	14.993	May 17,	14.981	May 19,	14.981
16,	14.984	18,	14.979	20,	14.985

Mean total pressure, May 15-20 = 14.984 atms.
Mean barom. pressure, May 15-20 = 0.994 atms.
Mean osmot. pressure, May 15-20 = 13.990 atms.
Mean osmotic pressure for Expts. 1 and 2 = 13.9905 atms.
Ratio of osmotic to gas pressure = 1.000

Table XXXIX

0.6 Wt. normal solution. Expt. 1 at 30°. Cell 105. Resistance, 250,000 ohms. Manometer 24. Calc. gas pressure, 14.830 atms. Time of setting up cell, Oct. 5, 1911. Barometer during final record: max., 1.008; min., 0.989. Total daily pressures:

Final Record.

	Atms.		Atms.		Atms.
Oct. 7,	16.672	Oct. 10,	16.702	Oct. 12,	16.693
8,	16.771	11,	16.694	13,	16.699
9,	16.713				(7 days)

Mean total pressure, Oct. 7-13 = 16.706 atms.
Mean barom. pressure, Oct. 7-13 = 1.000 atms.
Mean osmot. pressure, Oct. 7-13 = 15.706 atms.

Table XL.

0.6 Wt. normal solution. Expt. 2 at 30°. Cell H_5. Resistance, 200,000 ohms. Manometer 15. Calc. gas pressure, 14.830 atms. Time of setting up cell, Oct. 5, 1911. Barometer during final record: max., 1.008; min., 0.993. Total daily pressures:

Final Record

	Atms.		Atms.		Atms.
Oct. 9,	16.733	Oct. 13,	16.688	Oct. 16,	16.691
10,	16.698	14,	16.683	17,	16.688
11,	16.691	15,	16.684	18,	16.688
12,	16.693				(10 days)

Mean total pressure, Oct. 9-18 = 16.6937 atms.
Mean barom. pressure, Oct. 9-18 = 1.000 atm.
Mean osmot. pressure, Oct. 9-18 = 15.6937 atms.

Table XLI.

0.6 Wt. normal solution. Expt. 1 at 50°. Cell C_5. Resistance, 59,000 ohms. Manometer 31. Calc. gas pressure, 15.810 atms. Time of setting up cell, January 5, 1912. Barometer during final record: max., 1.019; min., 0.988. Total daily pressures:

Final Record

	Atms.		Atms.		Atms.
Jan. 10,	17.322	Jan. 15,	17.318	Jan. 19,	17.318
11,	17.339	16,	17.323	20,	17.320
12,	17.332	17,	17.318	21,	17.324
13,	17.333	18,	17.320	22,	17.320
14,	17.337				(13 days)

Mean total pressure, Jan. 10-22 = 17.325 atms.
Mean barom. pressure, Jan. 10-22 = 1.003 atms.
Mean osmot. pressure, Jan. 10-22 = 16.322 atms.

Table XLII.

0.6 Wt. normal solution. Expt. 2 at 50°. Cell R_5. Resistance, 118,000 ohms. Manometer 5. Calc. gas pressure, 15.810 atms. Time of setting up cell, January 5, 1912. Barometer during final record: max., 1.019; min., 0.988. Total pressures after cell became constant:

Final Record

	Atms.		Atms.		Atms.
Jan. 12,	17.302	Jan. 16,	17.309	Jan. 20,	17.316
13,	17.296	17,	17.313	21,	17.313
14,	17.321	18,	17.302	22,	17.312
15,	17.313	19,	17.301		(11 days)

Mean total pressure, Jan, 12-22 = 17.309 atms.
Mean barom. pressure, Jan. 12-22 = 1.003 atms.
Mean osmot. pressure, Jan. 12-22 = 16.306 atms.
Mean osmotic pressure for Expts. 1 and 2 = 16.319 atms.
Ratio of osmotic to gas pressure = 1.032.

Table XLIII

0.6 Wt. normal solution. Expt. 1 at 60°. Cell R_5. Resistance, 29,000 ohms. Manometer 11. Calc. gas pressure, 16.300 atms. Time of setting up cell, March 6, 1912. Barometer during final record: max., 1.015; min., 0.985. Total pressures after cell became constant:

Final Record

	Atms.		Atms.		Atms.
Mar. 13,	17.487	Mar. 16,	17.499	Mar. 19,	17,517
14,	17.498	17,	17.485	20,	17.546
15,	17.578	18,	17.522	21,	17.531

Mean total pressure, Mar. 13-21 = 17.518 atms.
Mean barom. pressure, Mar. 13-21 = 0.999 atms.
Mean osmot. pressure, Mar. 13-21 = 16.519 atms.

Table XLIV

0.6 Wt. normal solution. Expt. 2 at 60°. Cell P_5 Resistance, 23,000 ohms. Manometer 5. Calc. gas pressure, 16.300 atms. Time of setting up cell, March 6, 1912. Barometer during final record: max., 1.015; min., 0.985. Total pressures after cell became constant:

Final Record

	Atms.		Atms.		Atms.
Mar. 13,	17.555	Mar. 16,	17.553	Mar. 19,	17.527
14,	17.616	17,	17.523	20,	17.523
15,	17.585	18,	17.553	21,	17.519

Mean total pressure, Mar. 13-21 = 17.550 atms.
Mean barom. pressure, Mar. 13-21 = 0.999 atm.
Mean osmot. pressure, Mar. 13-21 = 16.551 atms.
Mean osmotic pressure for Expts. 1 and 2 = 16.535 atms.
Ratio of osmotic to gas pressure = 1.014.

Table XLV

0.6 Wt. normal solution. Expt. 1 at 70°. Cell B_5. Resistance, 10,000 ohms. Manometer 31. Calc. gas pressure, 16.790 atms. Time of setting up cell, May 10, 1912. Barometer during final record: max., 1.002; min., 0.985. Total daily pressures:

Final Record

	Atms.		Atms.		Atms.
May 11,	17.812	May 13,	17.824	May 15,	17.800
12,	17.820	14,	17.816	16,	17.795

Mean total pressure, May 11-17 = 17.810 atms.
Mean barom. pressure, May 11-17 = 0.995 atms.
Mean osmot. pressure, May 11-17 = 16.815 atms.

Table XLVI

0.6 Wt. normal solution. Expt. 2 at 70°. Cell W_5. Resistance, 16,400 ohms. Manometer 15. Calc. gas pressure, 16.790 atms. Time of setting up cell, May 9, 1912. Barometer during final record: max., 1.004; min., 0.982. Total daily pressures:

Final Record

	Atms.		Atms.		Atms.
May 13,	17.859	May 15,	17.817	May 17,	17.817
14,	17.822	16,	17.801	18,	17.800

Mean total pressure, May 13-18 = 17.819 atms.
Mean barom. pressure, May 13-18 = 0.995 atm.
Mean osmot. pressure, May 13-18 = 16.824 atms.
Mean osmotic pressure for Expts. 1 and 2 = 16.8195 atms.
Ratio of osmotic to gas pressure = 1.0018.

Table XLVII

0.7 Wt. normal solution. Expt. 1 at 50°. Cell D_3. Resistance, 110,000 ohms. Manometer 29. Calc. gas pressure, 18.445 atms. Time of setting up cell, December 14, 1911. Barometer during final record: max., 1.003; min., 0.981. Total pressures after cell became constant:

Final Record

	Atms.		Atms.		Atms.
Dec. 23,	20.272	Dec. 25,	20.211	Dec. 27,	20.194
24,	20.237	26,	20.211	28,	20.198

Mean total pressure, Dec. 23-28 = 20.2205 atms.
Mean barom. pressure, Dec. 23-28 = 0.996 atm.
Mean osmot. pressure, Dec. 23-28 = 19.2245 atms.

Table XLVIII

0.7 Wt. normal solution. Expt. 2 at 50°. Cell Z_3. Resistance, 150,000 ohms. Manometer 4. Calc. gas pressure, 18.445 atms. Time of setting up cell, December 14, 1911. Barometer during final record: max., 1.003; min., 0.981. Total pressures after cell became constant:

Final Record

	Atms.		Atms.		Atms.
Dec. 22,	20.297	Dec. 25,	20.178	Dec. 27,	20.143
23,	20.103	26,	20.164	28,	20.164
24,	20.186				

Mean total pressure, Dec. 22-28 = 20.1764 atms.
Mean barom. pressure, Dec. 22-28 = 0.997 atm.
Mean osmot. pressure, Dec. 22-28 = 19.1794 atms.
Mean osmotic pressure for Expts. 1 and 2 = 19.2019 atms.
Ratio of osmotic to gas pressure = 1.041.

Table XLIX

0.7 Wt. normal solution. Expt. 1 at 60°. Cell Z_5. Resistance, 27,000 ohms. Manometer 39. Calc. gas pressure, 19.017 atms. Time of setting up cell, March 14, 1912. Barometer during final record: max., 1.014; min., 0.984. Total daily pressures:

Final Record

	Atms.		Atms.		Atms.
Mar. 19,	20.319	Mar. 23,	20.450	Mar. 26,	20.438
20,	20.357	24,	20.444	27,	20.426
21,	20.362	25,	20.441	28,	20.410
22,	20.371				(10 days)

Mean total pressure, March 19-28 = 20.4018 atms.
Mean barom. pressure, March 19-28 = 0.999 atm.
Mean osmot. pressure, March 19-28 = 19.4028 atms.

Table L

0.7 Wt. normal solution. Expt. 2 at 60°. Cell A_5. Resistance, 58,000 ohms. Manometer 31. Calc. gas pressure, 19.017 atms. Time of setting up cell, March 14, 1912. Barometer during final record: max., 1.014; min., 0.974. Total pressures after cell became constant:

Final Record

	Atms.		Atms.		Atms.
Mar. 22,	20.428	Mar. 26,	20.400	Mar. 30,	20.395
23,	20.409	27,	20.390	31,	20.395
24,	20.417	28,	20.400	Apr. 1,	20.395
25,	20.416	29,	20.395		(11 days)

Mean total pressure, March 22-April 1 = 20.4036 atms.
Mean barom. pressure, March 22-April 1 = 0.999 atm.
Mean osmot. pressure, March 22-April 1 = 19.4046 atms.
Mean osmotic pressure for Expts. 1 and 2 = 19.4037 atms.
Ratio of osmotic to gas pressure = 1.020.

Table LI

0.7 Wt. normal solution. Expt. 1 at 70°. Cell J_5 Resistance, 8,000 ohms. Manometer 38. Calc. gas pressure, 19.587 atms. Time of setting up cell, May 2, 1912. Barometer during final record: max., 0.998; min., 0.984. Total pressures after cell became constant:

Final Record

	Atms.		Atms.		Atms.
May 8,	20.557	May 10,	20.516	May 12,	20.528
9,	20.564	11,	20.516	13,	20.534

Mean total pressure, May 8-13 = 20.543 atms.
Mean barom. pressure, May 8-13 = 0.990 atm.
Mean osmot. pressure, May 8-13 = 19.553 atms.

Table LII

0.7 Wt. normal solution. Expt. 2 at 70°. Cell F_5. Resistance, 10,000 ohms. Manometer 24. Calc. gas pressure, 19.589 atms. Time of setting up cell, May 11, 1912. Barometer during final record: max., 1.004; min., 0.982. Total daily pressures:

Final Record

	Atms.		Atms.		Atms.
May 13,	20.559	May 15,	20.600	May 17,	20.578
14,	20.574	16,	20.592	18,	20.566

Mean total pressure, May 13-18 = 20.577 atms.
Mean barom. pressure, May 13-18 = 0.994 atm.
Mean osmot. pressure, May 13-18 = 19-583 atms.
Mean osmotic pressure for Expts. 1 and 2 = 19.568 atms.
Ratio of osmotic to gas pressure = 0.999.

Table LIII

0.8 Wt. normal solution. Expt. 1 at 50°. Cell C_5. Resistance, 110,000 ohms. Manometer 28. Calc. gas pressure, 21.080 atms. Time of setting up cell, December 12, 1911. Barometer during final record: max., 1.014; min., 0.989. Total daily pressures:

Final Record

	Atms.		Atms.		Atms.
Dec. 13,	23.095	Dec. 18,	23.146	Dec. 23,	23.115
14,	23.116	19,	23.146	24,	23.075
15,	23.180	20,	23.158	25,	23.095
16,	23.164	21,	23.165	26,	23.115
17,	23.164	22,	23.135		(14 days)

Mean total pressure, Dec. 13-26 = 23.1335 atms.
Mean barom. pressure, Dec. 13-26 = 1.005 atms.
Mean osmot. pressure, Dec. 13-26 = 22.1285 atms.

Table LIV

0.8 Wt. normal solution. Expt. 2 at 50°. Cell J_5. Resistance, 100,000 ohms. Manometer 31. Calc. gas pressure, 21.080 atms. Time of setting up cell, December 12, 1911. Barometer during final record: max., 1.014; min., 0.989. Total daily pressures:

Final Record

	Atms.		Atms.		Atms.
Dec. 15,	23.069	Dec. 20,	23.149	Dec. 24,	23.103
16,	23.079	21,	23.131	25,	23.118
17,	23.068	22,	23.122	26,	23.107
18,	23.102	23,	23.107		
19,	23.135				(12 days)

Mean total pressure, Dec. 15-26 = 23.1075 atms.
Mean barom. pressure, Dec. 15-26 = 1.004 atms.
Mean osmot. pressure, Dec. 15-26 = 22.1035 atms.
Mean osmotic pressure for Expts. 1 and 2 = 22.116 atms.
Ratio of osmotic to gas pressure = 1.049.

Table LV

0.8 Wt. normal solution. Expt. 1 at 60°. Cell P_5. Resistance, 25,000 ohms. Manometer 1. Calc. gas pressure, 21.734 atms. Time of setting up cell, March 26, 1912. Barometer during final record: max., 1.012; min., 0.977. Total daily pressures:

Final Record

	Atms.		Atms.		Atms.
Mar. 28,	23.358	Apr. 1,	23.345	Apr. 5,	23.348
29,	23.339	2,	23.339	6,	23.339
30,	23.348	3,	23.318	7,	23.325
31,	23.348	4,	23.357	8,	23.339

(12 days)

Mean total pressure, Mar. 28-Apr. 8 = 23.342 atms.
Mean barom. pressure, Mar. 28-Apr. 8 = 0.998 atm.
Mean osmot. pressure, Mar. 28-Apr. 8 = 22.344 atms.

Table LVI

0.8 Wt. normal solution. Expt. 2 at 60°. Cell E_5. Resistance, 20,000 ohms. Manometer 15. Calc. gas pressure, 21.734 atms. Time of setting up cell, March 26, 1912. Barometer during final record: max., 1.012; min., 0.977. Total daily pressures:

Final Record

	Atms.		Atms.		Atms.
Mar. 30,	23.291	Apr. 3,	23.286	Apr. 7,	23.257
31,	(not rec'd)	4,	23.312	8,	23.349
Apr. 1,	23.329	5,	23.276	9,	23.345
2,	23.316	6,	23.298	10,	23 323

(12 days)

Mean total pressure, March 30-April 10 = 23.308 atms.
Mean barom. pressure, March 30-April 10 = 0.998 atm.
Mean osmot. pressure, March 30-April 10 = 22.310 atms.
Mean osmotic pressure for Expts. 1 and 2 = 22.327 atms.
Ratio of osmotic to gas pressure = 1.027.

Table LVII

0.8 Wt. normal solution. Expt. 1 at 70°. Cell U_5. Resistance, 23,000 ohms. Manometer 31. Calc. gas pressure, 22.387 atms. Time of setting up cell, April 29, 1912. Barometer during final record: max., 0.998; min., 0.984. Total pressures after cell became constant:

Final Record

	Atms.		Atms.		Atms.
May 5,	23.555	May 7,	23.547	May 9,	23.547
6,	23.549	8,	23.562	10,	23.568

Mean total pressure, May 5-10 = 23.559 atms.
Mean barom. pressure, May 5-10 = 0.992 atm.
Mean osmot. pressure, May 5-10 = 22.567 atms.

Table LVIII

0.8 Wt. normal solution. Expt. 2 at 70°. Cell R_5. Resistance, 10,000 ohms. Manometer 31. Calc. gas pressure, 22.387 atms. Time of setting up cell, May 16, 1912. Barometer during final record: max., 1.005; min., 1.001. Total daily pressures:

Final Record

	Atms.		Atms.		Atms.
May 18,	23.568	May 20,	23.556	May 22,	23.576
19,	23.565	21,	23.583		

Mean total pressure, May 18-22 = 23.570 atms.
Mean barom. pressure, May 18-22 = 1.003 atms.
Mean osmot. pressure for Expts. 1 and 2 = 22.567 atms.
Ratio of osmotic to gas pressure = 1.008

Table LIX

0.8 Wt. normal solution. Expt. 1 at 80°. Cell B_5. Resistance, 9,000 ohms. Manometer 24. Calc. gas pressure, 23.041 atms. Time of setting up cell, May 18, 1912. Barometer during final record: max., 1.004; min., 0.991. Total daily pressures:

Final Record

	Atms.		Atms.		Atms.
May 22,	24.087	May 24,	24.042	May 25,	24.036
23,	24.073				

Mean total pressure, May 22-25 = 24.060 atms.
Mean barom. pressure, May 22-25 = 0.998 atm.
Mean osmot. pressure, May 22-25 = 23.062 atms.
Ratio of osmotic to gas pressure = 1.001

Table LX

0.9 Wt. normal solution. Expt. 1 at 50°. Cell G_5. Resistance, 100,000 ohms. Manometer 1. Calc. gas pressure, 23.715 atms. Time of settting up cell, November 22, 1911. Barometer during final record: max., 1.013; min., 0.984. Total daily pressures:

Final Record

	Atms.		Atms.		Atms.
Nov. 26,	26.103	Nov. 30,	26.115	Dec. 3,	26.127
27,	26.127	Dec. 1,	26.139	4,	26.150
28,	26.133	2,	26.161	5,	26.139
29,	26.127				(10 days)

Mean total pressure, Nov. 26-Dec. 5 = 26.132 atms.
Mean barom. pressure, Nov. 26-Dec. 5 = 1.000 atm.
Mean osmot. pressure, Nov. 26-Dec. 5 = 25.132 atms.

Table LXI

0.9 Wt. normal solution. Expt. 2 at 50°. Cell F_3. Resistance, 100,000 ohms. Manometer 38. Calc. gas pressure, 23.715 atms. Time of setting up cell, Nov. 22, 1911. Barometer during final record: max., 1.013; min., 0.984. Total daily pressures:

Final Record

	Atms.		Atms.		Atms.
Nov. 26,	26.128	Nov. 30,	26.108	Dec. 3,	26.105
27,	26.142	Dec. 1,	26.082	4,	26.107
28,	26.127	2,	26.105	5,	26.108
29,	26.124				(10 days)

Mean total pressure, Nov. 26-Dec. 5 = 26.1136 atms.
Mean barom. pressure, Nov. 26-Dec. 5 = 1.000 atm.
Mean osmot. pressure, Nov. 26-Dec. 5 = 25.1136 atms.
Mean osmotic pressure for Expts. 1 and 2 = 25.1228 atms.
Ratio of osmotic to gas pressure = 1.0593

Table LXII

0.9 Wt. normal solution. Expt. 1 at 60°. Cell G_3. Resistance, 38,000 ohms. Manometer 28. Calc. gas pressure, 24.450 atms. Time of setting up cell, March 11. 1912. Barometer during final record: max., 1.014; min., 0.984. Total pressures after cell became constant:

Final Record

	Atms.		Atms.		Atms.
Mar. 22,	26.208	Mar. 26,	26.260	Mar. 30,	26.269
23,	26.225	27,	26.262	31,	26.269
24,	26.237	28,	26.264	Apr. 1	26.283
225,	26.250	29,	26.271		(11 days)

Mean total pressure, Mar. 22-Apr. 1 = 26.2544 atms.
Mean barom. pressure, Mar. 22-Apr. 1 = 0.998 atm.
Mean osmot. pressure, Mar. 22-Apr. 1 = 25.2564 atms.

Table LXIII

0.9 Wt. normal solution. Expt. 2 at 60°. Cell U_5. Resistance, 23,000 ohms. Manometer 5. Calc. gas pressure, 24,450 atms. Time of setting up cell, March 18, 1912. Barometer during final record: max., 1.014; min., 0.984. Total daily pressures:

Final Record

	Atms.		Atms.		Atms.
Mar. 22,	26.234	Mar. 26,	26.276	Mar. 30,	26.281
23,	26.234	27,	26.287	31,	26.321
24,	26.234	28,	26.283	Apr. 1,	26.342
25,	26.256	29,	26.276		(11 days)

Mean total pressure, Mar. 22-Apr. 1 = 26.274 atms.
Mean barom. pressure, Mar. 22-Apr. 1 = 0.999 atm.
Mean osmot. pressure, Mar. 22-Apr. 1= 25.275 atms.
Mean osmotic pressure for Expts. 1 and 2 = 25.2657 atms.
Ratio of osmotic to gas pressure = 1.0334

Table LXIV

0.9 Wt. normal solution. Expt. 1 at 70°. Cell F_5. Resistance, 19,100 ohms. Manometer 24. Calc. gas pressure, 25.186 atms. Time of setting up cell, April 19, 1912. Barometer during final record: max., 1.016; min., 0.984. Total pressures after cell became constant:

Final Record

	Atms.		Atms.		Atms.
May 1,	26.543	May 4,	26.562	May 6,	26.549
2,	26.593	5,	26.523	7,	26.574
3,	26.556				(7 days)

Mean total pressure, May 1-7 = 26.557 atms.
Mean barom. pressure, May 1-7 = 0.998 atm.
Mean osmot. pressure, May 1-7 = 25.559 atms.

Table LXV

0.9 Wt. normal solution. Expt. 2 at 70°. Cell R_5. Resistance, 16,500 ohms. Manometer 28. Calc. gas pressure, 25.186 atms. Time of setting up cell, April 29, 1912. Barometer during final record: max., 1.002; min., 0.989. Total daily pressures:

Final Record

	Atms.		Atms.		Atms.
May 3,	26.589	May 5,	26.565	May 7,	26.551
4,	26.590	6,	26.559		(5 days)

Mean total pressure, May 3-7 = 26.571 atms.
Mean barom. pressure, May 3-7 = 0.997 atm.
Mean osmot. pressure, May 3-7 = 25.574 atms.

Table LXVI

0.9 Wt. normal solution. Expt. 3 at 70°. Cell C_5. Resistance, 7,700 ohms. Manometer 1. Calc. gas pressure, 25.186 atms. Time of setting up cell, April 29, 1912. Barometer during final record: max., 1.002; min., 0.989. Total daily pressures:

Final Record

	Atms.		Atms.		Atms.
May 2,	26.552	May 4,	26.552	May 6,	26.563
3,	26.534	5,	25.564	7,	26.541

Mean total pressure, May 2-7 = 26.551 atms.
Mean barom. pressure, May 2-7 = 0.997 atms.
Mean osmot. pressure, May 2-7 = 25.554 atms.
Mean osmot. pressure for Expts. 1, 2 and 3 = 25.562 atms.
Ratio of osmotic to gas pressure = 1.015

Table LXVII

0.9 Wt. normal solution. Expt. 1 at 80°. Cell E_5. Resistance, 10,000 ohms. Manometer 31. Calc. gas pressure, 25.921 atms. Time of setting up cell, May 23, 1912. Barometer during final record: max., 1.001; min., 0.991. Total daily pressures:

Final Record

	Atms.		Atms.		Atms.
May 24,	26.905	May 26,	26.914	May 27,	26.919
25,	26.909				

Mean total pressure, May 24-27 = 26.912 atms.
Mean barom. pressure, May 24-27 = 0.997 atm.
Mean osmot. pressure, May 24-27 = 25.915 atms.

Table LXVIII

0.9 Wt. normal solution. Expt. 2 at 80°. Cell G_5. Resistance, 10,000 ohms. Manometer 5. Calc. gas pressure, 25.921 atms. Time of setting up cell, May 20, 1912. Barometer during final record: max., 1.001; min., 0.991. Total daily pressures:

Final Record

	Atms.		Atms.		Atms.
May 23,	26.974	May 25,	26.909	May 27,	26.909
24,	26.933	26,	26.873		

Mean total pressure, May 23-27 = 26.920 atms.
Mean barom. pressure, May 23-27 = 0.998 atm.
Mean osmot. pressure, May 23-27 = 25.922 atms.
Mean osmotic pressure for Expts. 1 and 2 = 25.919 atms.
Ratio of osmotic to gas pressure = 1.000

Table LXIX

1.0 Wt. normal solution. Expt. 1 at 50°. Cell R_3. Resistance, 55,000 ohms. Manometer 9. Calc. gas pressure, 26.350 atms. Time of setting up cell, June 17, 1910. Barometer during final record: max., 0.996; min., 0.991. Total daily pressures:

Final Record

	Atms.		Atms.		Atms.
June 18,	29.194	June 21,	29.178	June 23,	29.230
19,	29.177	22,	29.193	24,	29.194
20,	29.186				

Mean total pressure, June 18-24 = 29.193 atms.
Mean barom. pressure, June 18-24 = 0.994 atm.
Mean osmot. pressure, June 18-24 = 28.199 atms.

Table LXX

1.0 Wt. normal solution. Expt. 2 at 50°. Cell P_5. Resistance, 110,000 ohms. Manometer 29. Calc. gas pressure, 26.350 atms. Time of setting up cell, November 15, 1911. Barometer during final record: max., 1.008; min., 0.977. Total daily pressures:

Final Record

	Atms.		Atms.		Atms.
Nov 17,	29.230	Nov. 21,	29.225	Nov. 25,	29.213
18,	29.228	22,	29.221	26,	29.209
19,	29.250	23,	29.240	27,	29.213
20,	29.236	24,	29.243		(11 days)

Mean total pressure, Nov. 17-27 = 29.228 atms.
Mean barom. pressure, Nov. 17-27 = 0.997 atm.
Mean osmot. pressure, Nov. 17-27 = 28.231 atms.

Table LXXI

1.0 Wt. normal solution. Expt. 3 at 50°. Cell E_5. Resistance, 62,000 ohms. Manometer 5. Calc. gas pressure, 26.350 atms. Time of setting up cell, November 18, 1911. Barometer during final record: max., 1.008; min., 0.984. Total daily pressures:

Final Record

	Atms.		Atms.		Atms.
Nov. 23,	29.130	Nov. 27,	29.218	Dec. 1,	29.224
24,	29.153	28,	29.211	2,	29.211
25,	29.164	29,	29.218	3,	29.211
26,	29.150	30,	29.164	4,	29.224
					(12 days)

Mean total pressure, Nov. 23-Dec. 4 = 29.190 atms.
Mean barom. pressure, Nov. 23-Dec. 4 = 0.994 atm.
Mean osmot. pressure, Nov. 23-Dec. 4 = 28.196 atms.
Mean osmotic pressure for Expts. 1, 2 and 3 = 28.213 atms.
Ratio of osmotic to gas pressure = 1.071

Table LXXII

1.0 Wt. normal solution. Expt. 1 at 60°. Cell W_5. Resistance, 3,200 ohms. Manometer 11. Calc. gas pressure, 27.167 atms. Time of setting up cell, March 21, 1911. Barometer during final record: max., 1.005; min., 0.977. Total daily pressures:

Final Record

	Atms.		Atms.		Atms.
Mar. 24,	29.358	Mar. 28,	29.339	Mar. 31,	29.371
25,	29.298	29,	29.371	Apr. 1,	29.380
26,	29.309	30,	29.439	2,	29.358
27,	29.282				(10 days)

Mean total pressure, Mar. 24-Apr. 2 = 29.351 atms.
Mean barom. pressure, Mar. 24-Apr. 2 = 0.994 atm.
Mean osmot. pressure, Mar. 24-Apr. 2 = 28.357 atms.

Table LXXIII

1.0 Wt. normal solution. Expt. 2 at 60°. Cell L_6. Resistance, 30,000 ohms. Manometer 5. Calc. gas pressure, 27.167 atms. Time of setting up cell, March 25, 1911. Barometer during final record: max., 1.012; min., 0.976. Total daily pressures:

Final Record

	Atms.		Atms.		Atms.
Mar. 29,	29.319	Apr. 2,	29.377	Apr. 6,	29.399
30,	29.353	3,	29.405	7,	29.399
31,	29.331	4,	29.383	8,	29.421
Apr. 1,	29.358	5,	29.377		(11 days)

Mean total pressure, Mar. 29-Apr. 8 = 29.375 atms.
Mean barom. pressure, Mar. 29-Apr. 8 = 0.999 atm.
Mean osmot. pressure, Mar. 29-Apr. 8 = 28.376 atms.
Mean osmotic pressure for Expts. 1 and 2 = 28.3665 atms.
Ratio of osmotic to gas pressure = 1.044

Table LXXIV

1.0 Wt. normal solution. Expt. 1 at 70°. Cell G_6. Resistance, 30,000 ohms. Manometer 28. Calc. gas pressure, 27.984 atms. Time of setting up cell, April 15, 1912. Barometer during final record: max., 1.016; min., 0.983. Total daily pressures:

Final Record

	Atms.		Atms.		Atms.
Apr. 19,	29.542	Apr. 22,	29.630	Apr. 25,	29.589
20,	29.558	23,	29.591	26,	29.607
21,	29.599	24,	29.585	27,	29.610

Mean total pressure, Apr. 19-27 = 29.590 atms.
Mean barom. pressure, Apr. 19-27 = 1.00 atm.
Mean osmot. pressure, Apr. 19-27 = 28.590 atms.

Table LXXV

1.0 Wt. normal solution. Expt. 2 at 70°. Cell L_5. Resistance, 33,000 ohms. Manometer 5. Calc. gas pressure, 27.984 atms. Time of setting up cell, April 15, 1912. Barometer during final record: max., 1.016; min., 0.983. Total daily pressures:

Final Record

	Atms.		Atms.		Atms.
Apr. 17,	29.676	Apr. 21,	29.720	Apr. 25,	29.617
18,	29.623	22,	29.715	26,	29.646
19,	29.720	23,	29.635	27,	29.629
20,	29.746	24,	29.618		(11 days)

Mean total pressure, April 17-27 = 29.668 atms.
Mean barom. pressure, April 17-27 = 0.997 atm.
Mean osmot. pressure, April 17-27 = 28.671 atms.

Table LXXVI

1.0 Wt. normal solution. Expt. 3 at 70°. Cell E_5. Resistance, 20,000 ohms. Manometer 1. Calc. gas pressure, 27.984 atms. Time of setting up cell, April 15, 1912. Barometer during final record: max., 1.016; min., 0.983. Total daily pressures:

Final Record

	Atms.		Atms.		Atms.
Apr. 18,	29.572	Apr. 22,	29.617	Apr. 25,	29.587
19,	29.602	23,	29.610	26,	29.646
20,	29.602	24,	29.590	27,	29.632
21,	29.602				(10 days)

Mean total pressure, April 18-27 = 29.606 atms.
Mean barom. pressure, April 18-27 = 0.999 atm.
Mean osmot. pressure, April 18-27 = 28.607 atms.

Table LXXVII

1.0 Wt. normal solution. Expt. 4 at 70°. Cell R_5. Resistance, 33,000 ohms. Manometer 15. Calc. gas pressure, 27.984 atms. Time of setting up cell, April 15, 1912. Barometer during final record: max., 1.016; min., 0.983. Total daily pressure:

Final Record

	Atms.		Atms.		Atms.
Apr. 18,	29.608	Apr. 22,	29.628	Apr. 25,	29.596
19,	29.628	23,	29.600	26,	29.647
20,	29.635	24,	29.590	27,	29.700
21,	29.621				(10 days)

Mean total pressure, April 18-27 = 29.625 atms.

Mean barom. pressure, April 18-27 = 0.999 atm.

Mean osmot. pressure, April 18-27 = 28.626 atms.

Mean osmotic pressure for Expts. 1, 2, 3 and 4 = 28.6235 atms.

Ratio of osmotic to gas pressure = 1.0228

Table LXXVIII

1.0 Wt. normal solution. Expt. 1 at 80°. Cell H_5. Resistance, 10,500 ohms. Manometer 31. Calc. gas pressure, 28.801 atms. Time of setting up cell, May 27, 1912. Barometer during final record: max., 1.000; min., 0.986. Total daily pressures:

Final Record

	Atms.		Atms.		Atms.
May 28,	29.838	May 30,	29.801	May 31,	29.780
29,	29.811				

Mean total pressure, May 27-31 = 29.808 atms.

Mean barom. pressure, May 27-31 = 0.992 atm.

Mean osmot. pressure, May 27-31 = 28.816 atms.

Table LXXIX

1.0 Wt. normal solution. Expt. 2 at 80°. Cell L_6. Resistance, 10,000 ohms. Manometer 1. Calc. gas pressure, 28.801 atms. Time of setting up cell, May 27, 1912. Barometer during final record: max., 1.002; min., 0.993. Total daily pressures:

Final Record

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	Atms.		Atms.		Atms.
May 31,	29.770	June 3,	29.799	June 6,	29.859
June 1,	29.863	4,	29.785	7,	29.799
2,	29.836	5,	29.829		

Mean total pressure, May 31-June 7 = 29.8175 atms.
Mean barom. pressure, May 31-June 7 = 0.998 atm.
Mean osmot. pressure, May 31-June 7 = 28.8195 atms.
Mean osmotic pressure for Expts. 1 and 2 = 28.8178 atms.
Ratio of osmotic to gas pressure = 1.000

Table LXXX

	Weight-normal concentartion									
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
	Mean osmotic pressure in atmospheres									
Temp.										
0°	(2.462)	4.722	7.085	9.442	11.895	14.381	16.886	19.476	22.118	24.825
5°	2.452	4.818	7.198	9.608	12.100	14.605	17.206	19.822	22.478	25.283
10°	2.498	4.893	7.334	9.790	12.297	14.855	17.503	20.161	22.884	25.693
16°	2.541	4.985	7.476	9.949	12.549	15.144	17.815	20.535	23.305	26.189
20°	2.590	5.064	7.605	10.137	12.749	15.388	18.128	20.905	23.717	26.638
25°	2.634	5.148	7.729	10.296	12.943	15.624	18.434	21.252	24.126	27.053
30°	2.474	5.044	7.647	10.295	12.978	15.713	18.499	21.375	24.226	27.223
40°	2.560	5.163	7.844	10.599	13.355	16.146	18.932	21.803	24.735	27.701
50°	2.635	5.278	7.974	10.724	13.504	16.319	19.202	22.116	25.123	28.213
60°	2.717	5.437	8.140	10.866	13.666	16.535	19.404	22.327	25.266	28.367
70°	.....	.....	.....	11.194	13.991	16.820	19.568	22.567	25.562	28.624
80°	.....	.....	.....	.....	.....	.....	.....	23.062	25.919	28.818
90°	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
100°	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

Table LXXXI

Weight-normal concentration

Temp.	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
	Ratio of osmotic to gas pressure									
0°	(1.106)	1.061	1.061	1.060	1.069	1.077	1.083	1.093	1.104	1.115
5°	1.082	1.063	1.058	1.059	1.067	1.074	1.083	1.093	1.102	1.115
10°	1.082	1.060	1.059	1.060	1.066	1.073	1.083	1.092	1.102	1.113
15°	1.082	1.061	1.061	1.059	1.068	1.073	1.083	1.093	1.102	1.115
20°	1.084	1.062	1.060	1.060	1.067	1.073	1.084	1.093	1.103	1.115
25°	1.084	1.059	1.060	1.059	1.065	1.071	1.083	1.093	1.102	1.113
	(1.083)	(1.061)	(1.060)	(1.060)	(1.067)	(1.074)	(1.083)	(1.093)	(1.103)	(1.114)
30°	1.000	1.020	1.031	1.040	1.050	1.060	1.069	1.081	1.089	1.101
40°	1.003	1.011	1.024	1.038	1.046	1.054	1.059	1.067	1.076	1.085
50°	1.000	1.002	1.009	1.017	1.025	1.032	1.041	1.049	1.059	1.071
60°	1.000	1.001	0.999	1.000	1.006	1.015	1.020	1.027	1.033	1.044
70°	.....	.....	.....	1.000	1.000	1.002	0.999	1.008	1.015	1.023
80°	.....	.....	.....	.....	.....	.....	.....	1.001	1.000	1.000
90°	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
100°	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

DISCUSSION OF MEASUREMENTS.

Tables II to LXXIX give a somewhat detailed account of each experiment. It seemed desirable in this connection to recall the fact that the theoretical gas pressures given in these tables were calculated by means of the equation $p\ v = KT$ in which v is the volume of the solvent in the pure condition and at the temperature of maximum density, i. e., at 4° c. It is to be noted, also, that the value 0.00367 t has been employed in all calculations of pressure; hence, in so far as this coeficient is incorrect for nitrogen gas at the higher pressures, a correction is still to be applied to the osmotic pressures which are recorded in the Tables.

Table LXXX gives, for each of the 10 concentrations of solution, the osmotic pressures which have been found between 0° and the highest temperature at which measurements have been made in this laboratory up to the present 60°, being the highest temperature for 0.1, 0.2, 0.3, weight normal concentrations 70°, for 0.4, 0.5, 0.6, 0.7, weight normal solutions and 80° for 0.8, 0.9, 1.0 weight normal concentrations.

In Table LXXXI the osmotic pressures given in Table LXXX are given in the more convenient form of ratios of osmotic to gas pressure.

CONCLUSIONS.

The obvious conclusions to be drawn from Table LXXXI are:

1. Between 0° and 25°, all concentrations of cane-sugar solutions from 0.1 to 1.0 weight normal, obey strictly the law of Gay-Lussac for gases. The same is true of 0.1 normal solutions between 30° and 60°; and of the 0.2 normal solutions between 50° and 60°; and of the 0.4 normal solutions between 60° and 70°. In all the cases cited the ratio of osmotic to gas pressure is constant wthin the specified ranges of temperature.

2. Between 0° and 25°, the ratio of osmotic to gas pressure (which is constant, but greater than unity from 0° to 25°) begins to decline in all concentrations, but relatively more rapid in the more dilute solutions.

3. The decline in ratio, which begins between 25° and 30° continues at higher temperatures until osmotic pressure becomes in every instance, equal to the calculated gas pressure of the solute. It is not obvious whether the unit ratio, once reached, will be maintained at all higher temperatures; but the conduct of 0.1 normal solution between 30° and 60°, 0.2 normal solutions between 50° and 60° and of 0.4 normal solution between 60° and 70°, throws some light upon this important question.

4. The law of Boyle as well as that of Gay-Lussac hold in 15 cases in Table LXXXI; namely for 0.1 normal solutions at 30°, 40°, 50°, and 60°, 0.2 normal solution at 50°, and 60° 0.3 and 0.4 normal solutions at 60°, 0.4, 0.5, 0.6, 0.7, normal solutions at 70° and 0.8, 0.9, 1.0 normal solutions at 80°. On the other hand there is nowhere to be found in the table any convincing evidence that the law of Boyle does not hold for osmotic pressure.

BIOGRAPHY.

John Brown Zinn was born August 20, 1888, at Gettysburg, Pa. His early education was obtained at the public schools of that place, graduating in the spring of 1905. In the fall of that same year he entered Pennsylvania College, Gettysburg, Pa., and graduated in 1909, receiving the degree of Bachelor of Science. In 1910 he entered the graduate department of Johns Hopkins University majoring in Chemistry with Physical Chemistry and Geology as his first and second subordinate subjects respectively.

In 1911-1912 he held a university scholarship and in June 1912, was appointed a University Fellow for the year 1912-1913.